DYETT & BHATIA
Urban and Regional Planners

M E M O R A N D U M

To:	David de Cordova
From:	Chris Ford, Josh Pollak
Re:	Carlsbad Community Greenhouse Gas Inventory Update – 2011
Date:	August 26, 2013

This memo highlights the approach taken to update the City's 2005 Greenhouse Gas (GHG) Emissions Inventory with 2011 data and compares the inputs and outputs. A separate memo will cover local government operations. The content of these memos will then contribute to the summary of Carlsbad's GHG emissions in the forthcoming Climate Action Plan (CAP); the memos may be placed in an appendix to the CAP.

This memo reviews the assumptions employed, the quantitative inputs and methodology of estimating the emissions by sector, and the outputs.

Technical terms and acronyms that appear in this memo are listed in Table 1.

Table 1: Technical Terms and Acronyms

CACP	Clean Air and Climate Protection software, a model developed by ICLEI to inventory and forecast GHG emissions
CAP	Climate Action Plan
CARB	California Air Resources Board, the agency responsible for setting statewide GHG emission reduction targets. CARB also maintains several GHG emission calculation models.
CO_2e	Carbon dioxide equivalents, a measure of GHGs that converts non-CO_2 emissions to the same impact as carbon dioxide
EMFAC	The EMissions FACtors model developed by CARB to measure various emissions from vehicles. There are multiple versions of EMFAC which focus on different vehicle types.
EPA	US Environmental Protection Agency
GHG	Greenhouse gases, mainly carbon dioxide (CO_2), carbon dioxide, nitrous oxide (N_2O), and methane (CH_4)
ICLEI	An organization that provides standards and models for measuring and forecasting GHG emissions
SDG&E	San Diego Gas and Electric, the energy utility for Carlsbad
Service Population	Residents + employees, a rough measure of how many people may be generating emissions within a defined area.
VMT	Vehicle Miles Traveled, a measure of the annual amount of driving within an area, used to calculate GHG emissions from vehicles

755 Sansome St, Suite 400 | T 415 956 4300
San Francisco, CA 94111 | F 415 956 7315
www.dyettandbhatia.com

ASSUMPTIONS

As with the 2005 inventory, ICLEI's CACP[1] model was used to estimate emissions from residential, commercial, and industrial consumption of energy and solid waste disposal; CARB's EMFAC models were used to calculate transportation emissions; and other sources were used for wastewater and Palomar landfill emissions.

Between 2005 and 2011, the population and jobs of Carlsbad increased by an estimated 12 percent as did the service population of Carlsbad—the number of residents plus number of jobs, reflecting the number of people who may generate GHG emissions. Since 2005, Carlsbad's share of the county population has increased from 3.13 percent to 3.41 percent, due to a faster rate of growth than the overall county. Table 2 summarizes these changes.

Table 2: Population and Jobs, 2005 and 2011

	2005	*2011*	*% Change*
San Diego County Population[1]	3,034,388	3,115,810	2.7%
Carlsbad Population[1, 2]	94,961	106,403	12.0%
Carlsbad - % of County Population	3.13%	3.41%	8.9%
Carlsbad - # of Jobs[3]	59,309	66,417	12.0%
Carlsbad – Service Population	154,270	172,820	12.0%

1. The 2011 populations for the county and Carlsbad come from the California Department of Finance, Table E-5.
2. The 2005 Inventory used different populations for the community and local government analyses. This is the population used for the community inventory.
3. Numbers from SANDAG.

Electricity Coefficients

Electricity coefficients measure how much GHG emission and air pollution is created by various sources of electricity generation. They are measured as pounds of emission per megawatt hour (lb/MWh). The CACP model includes "back end" settings and assumptions that can be adjusted from defaults:

- Bundled customers purchase electricity from SDG&E. The CACP model has built-in values for SDG&E, although the most recent data is from 2007. Dudek provided 2010 numbers from SDG&E from the Climate Registry, which are the most recent available; these 2010 numbers were substituted in for the 2007 data.
- CACP also allows the manual entry of coefficients. This is used for direct electricity consumers, who purchase power from elsewhere, with SDG&E handling delivery to the customer. The power is purchased from across the region. We used the regional energy coefficients from the EPA's 2009 eGRID tables, which are the most recent available.

Table 3 compares the coefficients used for the 2005 and 2011 inventories. The table shows that since 2005, the pounds of GHG emissions (carbon dioxide, nitrous oxide, and methane) produced per megawatt hour of electricity fell for both SDG&E and regional power generation—except for

[1] The 2011 update utilized the CACP 2009 Version 3.0 software.

CO_2 emissions from SDG&E power, which rose significantly (35%). The reason for this difference is unknown; SDG&E would not respond to our questions. The coefficients for SDG&E in 2005 were notably lower than in all other recent years, however, with a major decline from 2004 to 2005, followed by large increases between 2005 and 2007, and thereafter. This pattern suggests that SDG&E's low energy coefficients for 2005 were abnormal, with the 2010 coefficients (used for the 2011 Inventory) more in line with recent trends.

A second issue shown by Table 3 is that in 2005, SDG&E power was significantly cleaner than power purchased from elsewhere (about 24% less CO_2), but by 2009-2010 SDG&E power produced more GHG emissions than other regional power (12% more CO_2).

Table 3: Electricity Coefficients (lb/MWh)

Year	*CO_2*	*N_2O*	*CH_4*
Bundled Service (SDG&E)			
2005[1]	546.50	0.011	0.030
2010[2]*	739.05	0.0081	0.0302
% Increase	*+35%*	*-26%*	*+1%*
Direct Access Electricity (eGRID)			
2005	724.12	0.00808	0.03024
2009[3]*	658.68	0.00617	0.02894
% Change	*-9%*	*-24%*	*-4%*

**Data used for Carlsbad 2011 inventory update.*

1. Data from CACP model.
2. Data from www.climateregistry.org
3. 2009 eGRID coefficients for N_2O and CH_4 converted from lb/GWh by dividing by 1,000. All 2009 coefficients are the "subregion annual total output emission rate."

Natural Gas Coefficients

The default values in the CACP model were used; they are the same as those used in 2005.

Transportation

We used the default assumptions for San Diego County within CARB's GHG emissions models, EMFAC2007 and OFFROAD2007 (from 2007) and EMFAC2011 (from 2011).

Solid Waste

The default values in the CACP model were used; they are the same as those used in 2005.

INPUTS AND METHODOLOGY

This section describes the data used to calculate 2011 emissions and the manner in which the data was acquired, transformed, and used. The 2005 emissions measurement process was organized

around source sector; this structure was maintained for the 2011 effort. The table at the end of this section compares the 2005 and 2011 inputs.

Residential / Commercial / Industrial (RCI)

The inputs for these three sectors are the same: inputs are electricity and natural gas consumed, broken into bundled and direct access, and entered into CACP. All of the data is from SDG&E.

- Bundled electricity is produced for SDG&E and transmitted by SDG&E. The electricity coefficients for SDG&E, based on the utility's mix of power sources and technology, determine the CO_2e produced.
- Direct access electricity is produced elsewhere in the region but ultimately transmitted to the consumer by SDG&E. Given the wide mix of possible producers, regional electricity coefficients are applied to determine CO_2e.
- Natural gas produces the same CO_2e regardless of source.

Table 4 shows the 2011 RCI inputs compared to the 2005 inputs. There were some changes between bundled and direct access service—see the data file for those details. Most energy consumption increased between 1.4 and 2.5 percent per year. The exceptionally high industrial natural gas consumption in 2005 appears to include use by the Encina Power Station, which was removed from the final numbers of that inventory; the 2011 Inventory data does not include the station.

Table 4: RCI Inputs

		2005	*2011*	*Change*	*Avg Annual*
Residential	Electric (kWh)	249,286,797	275,033,189	10%	1.7%
	Natural Gas (therms)	13,861,471	15,769,481	14%	2.2%
Commercial	Electric (kWh)	379,244,330	411,249,580	8%	1.4%
	Natural Gas (therms)	6,779,454	7,844,336	16%	2.5%
Industrial	Electric (kWh)	114,639,521	116,341,521	1%	0.2%
	Natural Gas (therms)	234,647,345*	1,536,470	-	-

*Includes use by Encina Power Station

Table 5 summarizes the communitywide consumption of electricity and natural gas. Electricity consumption grew at the rate of job creation and below the rate of population growth, but natural gas consumption grew faster than the city.

Table 5: Communitywide Summary of Electricity and Gas Consumption

	2005	*2011*	*Change*	*Avg Annual*
Electric (kWh)	743,170,648	802,624,290	8%	1.3%
Natural Gas (therms)*	20,640,925	23,613,817	14%	2.3%

*Excludes industrial

Transportation – Vehicles

The 2005 inventory used the EMFAC2007 model created by CARB due to its "regionally-specific information on the mix of vehicle classes and model years, as well as ambient conditions and travel speeds, that determine fuel efficiency." As inputs, emissions from local roadway VMT and freeway VMT were determined separately.

- Local roadway VMT was taken from the Caltrans HPMS (Highway Performance Monitoring System), which provides a citywide daily VMT for all local roadways except federal and state highways (i.e., I-5).
- Daily VMT for I-5 was acquired from SANDAG regional GIS files and clipped to the city limits.
- EMFAC2007 apparently produced CO_2 and CH_4 outputs in short tons (2,000 pounds) for each VMT, broken down by gasoline and diesel.
- CH_4 was converted into CO_2e by multiplying it by 21.
- Daily CO_2e was multiplied by 365 days and converted to metric tons, which are 1,000 kilograms, but multiplying "short tons" by 0.9072.
- The State highway CO_2e was also multiplied by 0.94 to convert weekday only data into average 7-day data.

For the 2011 inventory update, SANDAG provided 2008 and 2011 VMT data for two scenarios: the first which captures all VMT within the City of Carlsbad, the second excluding pass-through trips, or trips neither originating nor ending within the City of Carlsbad. Examples of pass-through trips are trips on the I-5 freeway and other major streets where drivers do not begin or end within the City of Carlsbad. Table 6 shows a comparison of VMT from 2005 and 2011 both including and excluding pass-through trips. In both 2005 and 2011, the VMT excluding pass-through trips was less than one-half of the total VMT.

Table 6: Annual Vehicle Miles Travelled within City of Carlsbad Including and Excluding Pass-Through Trips

	2005*	% of Total	2011	% of Total
VMT including pass-through trips	1,077,348,687	-	1,203,623,632	-
VMT excluding pass-through trips	505,241,237	47%	510,973,969	42%

*Estimated by linear interpolation of 2008 SANDAG data

The 2011 Inventory uses VMT excluding pass-through trips to capture transportation emissions from trips originating or ending within the City of Carlsbad. Residents, commuters and the City have a limited ability or are unable to influence pass-through trips, which contribute a substantial amount to VMT totals. Therefore, pass-through trips were excluded from this inventory.

Table 7 compares the 2005 annual VMT to 2011 VMT. The VMT in Carlsbad grew at a slower rate than population growth. The low rate of growth in VMT could have been caused by regional economic slowdown.

Table 7: Annual Vehicle Miles Travelled within City of Carlsbad Excluding Pass-Through Trips

	2005*	2011	Change	Avg Annual
VMT	505,241,237	510,973,969	1%	0.2%

*Estimated by linear interpolation from 2008 SANDAG data

The inventory update uses CARB's latest model, EMFAC2011, which is made up of three modules, -SG, -LDV, and –HD. The SG module covers all vehicle types, while LDV calculates light duty vehicles and HD calculates heavy duty vehicles.

- Carbon dioxide emissions were calculated using the SG module. The model was set to San Diego County, CY 2011, Annual, using the citywide annual VMT for 2011. We used the CO_2 emissions output that assumes Pavley I and low carbon fuel standard (LCFS).
- Methane emissions are not calculated by the SG module, so the LDV module was used to calculate CH_4 from light duty vehicles, with emissions from heavy duty vehicles calculated using a formula. We used the following process:
    - The SG module automatically distributes overall VMT into different vehicle types using a regionally-specific mix.
    - These SG vehicle types were compared to the vehicle models in the LDV module and manually categorized into light and heavy duty.
    - The VMT for light duty vehicles was then entered into the LDV module, which calculated CH_4 for light duty vehicles.
    - For heavy duty vehicles, we summed the Total TOG Emissions and multiplied by 0.0408 to get CH_4. Calculation is from CARB: http://www.arb.ca.gov/msei/emfac2011-faq.htm#emfac2011_web_db_qstn07

Transportation – Off Road

As with the 2005 inventory, CARB's OFFROAD2007 model was used. It was run with the settings: 2011 CY, Mon-Sun (all days), Annual, HC emissions as TOG, Area = San Diego County; all equipment, fuel, and horsepowers.

The model generates emission outputs for 16 categories across San Diego County. The 2005 inventory used 4 categories that generate the most emissions: lawn and garden equipment, construction equipment, industrial equipment, and light commercial equipment.

The CO2, N2O, and CH4 emissions are calculated in short tons per day for the county. These emissions were then pro-rated by the city's share of the county population, multiplied by 365 days, and converted to metric tons.

Solid Waste

For methane emissions from the one landfill in the city limits, the closed Palomar Airport Landfill, we used the same data from 2005 – it is unlikely to have changed much, if at all.

For emissions from solid waste disposed of in Carlsbad and taken to landfills elsewhere, 2011 data for Carlsbad was obtained from CalRecycle. The composition of waste was estimated from the latest such survey, the 2008 CalRecycle Statewide Waste Characterization Study, which has averages for the southern region of California. The amount of average daily cover, which is made of plant debris, was also entered.

Wastewater

As in 2005, the EPIC estimate of GHG emissions from countywide wastewater treatment was used and pro-rated to Carlsbad's share of the county population. For unknown reasons, countywide GHG emissions from wastewater treatment went up significantly from 2005 to 2011, increasing by 32 percent. While this emissions increase was not caused by Carlsbad per se, the community is considered responsible for it. That said, these emissions from wastewater make up a very small proportion of Carlsbad's overall GHG emissions.

OUTPUTS

The majority of emissions growth came from commercial and residential electricity and natural gas consumption, although this was highly influenced by the large increase in emissions from SDG&E electricity generation since 2005. Transportation emissions decreased by 5 percent, though VMT rose by 1 percent, likely a sign that cleaner vehicles are making an impact. Emissions from solid waste decreased along with the decline in the tonnage of waste disposed, possibly due to the economic recession, while emissions from wastewater treatment went up regionally but are a relatively small number. Table 8 summarizes the sources and amounts of communitywide emissions.

Table 8: GHG Emissions 2005 vs. 2011 (metric tons CO2e)

Sector	*Subsector*	*2005 Emissions*	*2011 Emissions*	*% Growth*	*Avg Annual Rate*
Residential	Bundled Electricity	62,105	92,500		
	Bundled Natural Gas	74,137	83,698		
	Direct Access Electricity	185	81		
	Direct Access Natural Gas	-	126		
	Total Residential	**136,427**	**176,405**	**29%**	**4.38%**
Commercial	Bundled Electricity	83,303	125,314		
	Bundled Natural Gas	35,843	37,731		
	Direct Access Electricity	15,049	11,701		
	Direct Access Natural Gas	416	3,966		
	Total Commercial	**134,611**	**178,712**	**33%**	**4.84%**
Industrial	Bundled Electricity	16,812	29,329		
	Bundled Natural Gas	3,013	-		
	Direct Access Electricity	15,605	8,765		
	Direct Access Natural	-	8,154		

	Gas				
	Total Industrial	**35,430**	**46,248**	**31%**	**4.54%**
Transportation	On-Road Total	260,467	239,467	-8%	-1.39%
	Lawn and Garden Equipment	2,099	2,449	17%	2.60%
	Construction Equipment	19,861	23,830	20%	3.08%
	Industrial Equipment	4,349	4,943	14%	2.16%
	Light Commercial Equipment	2,654	3,056	15%	2.38%
	Off-Road Subtotal	*28,963*	*34,279*	*18%*	*2.85%*
	Total Transportation	**289,430**	**273,745**	**-5%**	**-0.9%**
Solid Waste	Community-generated solid waste	27,417	21,719	-21%	-3.81%
	Landfill Waste-in-Place	2,598	2,598	0%	0.00%
	Total Solid Waste	**30,015**	**24,317**	**-19%**	**-3.45%**
Wastewater	Total Community-generated Wastewater	4,397	6,317	44%	6.23%
GRAND TOTALS		**630,310**	**705,744**	**12%**	**1.90%**

The RCI numbers in the above table can be hard to compare, due to growth in energy consumption being mixed with switches between bundled service and direct access. Table 9 summarizes emissions by power source and sector. From this table, it is clear that the relative and absolute increase in emissions from electricity is a major contributor to the communitywide growth in emissions.

Table 9: Emissions from Electricity and Natural Gas Summarized

Category	*2005 CO2e*	*2011 CO2e*	*% Growth*	*AARG*
Residential-Electric	62,290	92,581	49%	6.8%
Residential-NG	74,137	83,824	13%	2.1%
Commercial-Electric	98,352	137,015	39%	5.7%
Commercial-NG	36,259	41,697	15%	2.4%
Industrial-Electric	32,417	38,094	18%	2.7%
Industrial-NG	3,013	8,154	171%	18.0%
OVERALL RCI	**306,468**	**401,365**	**31%**	**4.6%**

CONCLUSIONS

Overall the communitywide GHG emissions from Carlsbad increased by 12 percent between 2005 and 2011, equivalent to the rate of population and job household growth during that time. As a result, the GHG emissions per service population held steady since 2005, as shown in Table 10.

Table 10: Emissions per Service Population

	2005	*2011*	*% Change*
GHG Emissions ($MTCO_2e$)	630,310	705,745	12.0%
Service Population	154,270	172,820	12.0%
Emissions per Service Population	4.09	4.08	-0.1%

Table 11 shows where the growth in emissions came from. The largest contributors to additional emissions came from commercial electricity usage (37%), followed by residential electricity usage (29%). All other emissions increased lower than the rate of population growth, with emissions from residential natural gas consumption increasing by 9 percent, and all other sources increasing by 5 percent, or decreasing, in the case of roadway emissions.

For electricity, this increase is largely fueled by the large increase (35%) in the CO_2 generated by SDG&E electricity since 2005. For example, residential electricity consumption increased by 10 percent but emissions from that source increased by 29 percent. Commercial electricity consumption went up by 8 percent while related emissions increased by 37 percent—an even higher increase as some commercial customers switched from cleaner direct access electricity to "dirtier" sources.

Table 11: Sources of Growth in GHG Emissions (metric tons CO2e)

Source	*2005 CO2e*	*2011 CO2e*	*Growth*	*% of Growth*
Commercial-Electric	98,352	137,015	38,663	37%
Residential-Electric	62,290	92,581	30,291	29%
Residential-NG	74,137	83,824	9,688	9%
Roads	260,467	239,467	-21,000	-8%
Industrial-Electric	32,417	38,093	5,676	5%
Commercial-NG	36,259	41,697	5,438	5%
Off Road	28,963	34,279	5,315	5%
Industrial-NG	3,013	8,154	5,141	5%
Wastewater	4,397	6,317	1,920	2%
Solid Waste	30,015	24,317	-5,698	-5%
TOTALS	**630,310**	**705,744**	**75,434**	

Table 12 shows the sources of emissions, ordered by volume of overall contribution. The largest contributor continues to be transportation, but that has declined in proportion as emissions from

energy consumption have grown faster. These sources—roadway VMT, off-road vehicles, and private electricity and natural gas consumption—account for 96 percent of Carlsbad's communitywide GHG emissions.

Table 12: Greenhouse Gas Emissions Summary by Sector (metric tons CO2e)

Sector	*2005*	*% of Total*	*2011*	*% of Total*
Transportation	289,431	46%	273,745	39%
Commercial / Industrial	170,041	27%	224,960	32%
Residential	136,427	22%	176,405	25%
Solid Waste	30,015	5%	24,317	3%
Wastewater	4,397	1%	6,317	1%
TOTAL	**630,310**		**705,744**	